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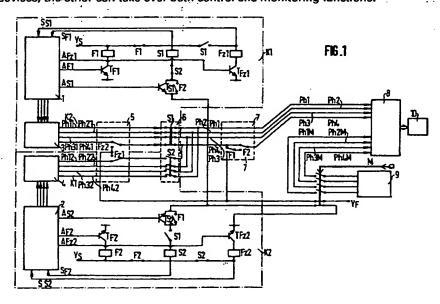
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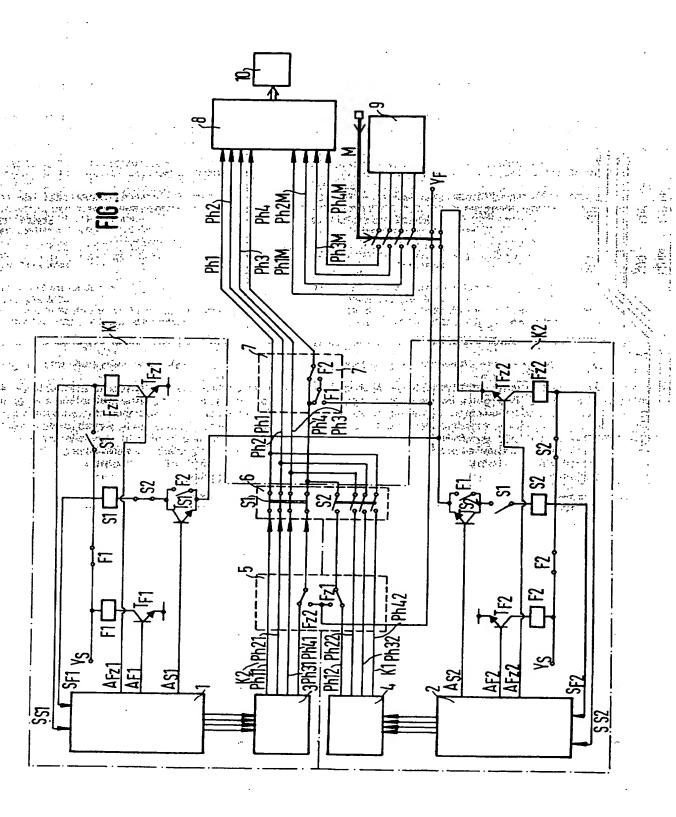
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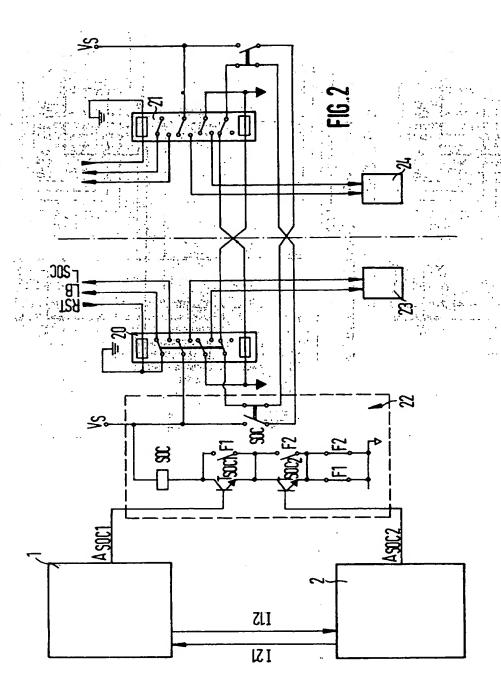
(54). Control system for shaft drive assembly

(57) Control of a shaft drive assembly is effected using a pair of micro control devices 1, 2 for controlling fuel metering by means of a metering valve 10 with a stepping motor 8, and for monitoring for shaft fracture and the same and t excessive rotational speed by means of sensors. The micro control devices 1, 2 can each carry out both control with the contr and monitoring functions. In normal mode the first micro control device 1 is the selected control device. Alara Maria 1994 and 1997 controlling the stepping motor 8 while the second micro control device 2 as the auxiliary control device. monitors the permitted boundary data of the engine. The micro control devices are coupled in such a way that the control and monitoring functions can be switched over between the devices. In the event of a failure of one of the control devices, the other can take over both control and monitoring functions.



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Shaft Drive Control

The invention relates to the control of a shaft drive assembly or engine with at least one micro control device such as a microprocessor for controlling the metering of fuel by means of a metering valve with a motor drive and/or channel cut-off logic, with monitoring of the engine for shaft fracture and excessive rotational speed by means of sensors.

Control systems of this type are known and operate typically with a large number of micro control devices.

The known control devices use separate micro control devices for controlling the supply of fuel monitoring the rotational speed of the engine or the shaft, and monitoring shaft fracture, as well as redundant micro control devices which, as supplementary or auxiliary control devices, double or triple the number of control devices required to reduce further the likelihood of a malfunction of a control device, which is about 10.5.

Even if micro control devices of this type are already minimised in volume and weight, using them in quantities in an aircraft means a considerable space and weight requirement.

It has also not been conclusively proved that a plurality of auxiliary micro control devices increases reliability; on the contrary, tests show that unused non-active auxiliary devices often fail to provide service at the decisive moment. A solution in this case is regular alternating use of the auxiliary devices and the main devices. This has the disadvantage that the auxiliary devices are intermittently inactive and still represent an additional space requirement and additional weight.

A further disadvantage is that often the micro control devices with a monitoring function have the sole function of switching off the engine when

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individual sensors indicate that limit values have been exceeded. This may lead to hasty and possibly catastrophic conclusions if the signals are incorrectly interpreted by a sensor.

It is the aim of the invention to provide a control system which manages with a reduced number of micro control devices, reduces the likelihood of incorrect functioning, can be used with great economy The second of space and weight, reduces the inactive phases of the the second weight, 10 445 micro control devices, and ensures an optimum control in the devices and no professional of shaft drive assemblies no refer no second second second second second second second second

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的表面的 the This aimgistachieved with the control of a shaft 数 (2) 不多的 () 的复数 for the second drive assembly with at least one micro control device the most second to 15 metering valve with a motor drive and channel cut-off and the logic, with monitoring of the drive assembly for whaft a Section 19 10 10 fracture and/ordexcessive rotational speed by means of with the factor of the contract of the 一点。如果我们是 Sensors, characterised in that a first and assecond and by 网络克里克拉拉克克 20 with respect to each other in partial functions, the first micro control device as the selected control device controlling a stepping motor which operates the metering valve, and the second micro control device as the auxiliary control device monitoring the permitted boundary data of the drive assembly and is equipped with driver outputs which according to the fault (fault in the control devices, shaft fracture, excessive rotational speed) freeze the stepping motor position by means of a first logic switch, or trigger a fast cutoff by means of a transistor driver with a second logic switch connected downstream, or make possible a delayed cut-off by means of the second logic switch, the selected and the auxiliary control device being coupled together by means of the first and second logic switches and an additional direct data line in such a way that the functions can be alternately switched over

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according to the setting of the first and second logic switches.

Two completely equivalent micro control devices are provided with completely equivalent functions but are not used simultaneously for the same function. On the contrary, a first micro control device controls the fuel consumption, for instance, whilst a second micro control device takes over the monitoring functions. Both devices are therefore constantly in use, i.e. one 10 mas the selected control device for fuel adjustment and the other asithe auxiliary device for all the comes and monitoring functions. In the case of total failure of one of the devices the other device can take over its provision is also advantageously made for 15 the devices to switch over, i.e. to exchange functions. with this concept, the likelihood of error is reduced to , thugh subjury gabout 10-7. a se garatis

paragraph to a first and a second micro control device are preferably joined together and locked with. 1.900 多形式 respect to each other in partial functions. The first micro control device acting as the selected control adevice controls a stepping motor, which operates the metering valve. The second micro control device, acting as the auxiliary control device, monitors the permitted boundary data of the engine and is equipped with driver outputs which freeze the stepping motor position by means of a first logic switch, or trigger a fast cut-off by means of a transistor driver with a second logic switch connected downstream, or in the case of excessive rotational speed make possible a delayed cut-off by means of the second logic switch. The selected and the auxiliary control device are coupled together by means of the first and second logic switches and an additional direct data line in such a way that the functions can be alternately switched over according to the position of the first and second logic

switches.

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This control concept not only increases the reliability of control and monitoring but is also costeffective and reduces the weight and space requirement in an aircraft.

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The invention is also directed to a method of controlling a shaft drive assembly.

In a preferred embodiment of the invention the ि कि निर्देश कि fast cut off is triggered by the auxiliary controls के कि । वाक कार का वाक कार विशेष 10 device and effected by the selected control device. This division of work has the advantage that monitoring in the best and the and the six of the form of the control of the carried out in the auxiliary of the control device at shorter intervals or cycles than the . The standard test for shaft fracture which is run in the war a comment of the 15 reselected micro control device, whose main task is fuel The state of the s the season intervals or cycles. However, if a shaft fracture of the last the seasons The Annual Control of this kind is signalled by the faster auxiliary control of the first of the faster auxiliary control of t device, then the standard cycle in the selected micro 200 Asscontrol device is interrupted by means of the data signal line and directly thereafter the shaft fracture test is carried out and on confirmation the fast cut-off of the fuel supply is brought about by the selected micro control device.

> * In a further preferred embodiment of the invention both micro control devices can carry out all the functions as individual devices during total failure of one control device, but the monitoring function for shaft rupture, in this case slowed down by the factor 3 to 10, is carried out by only one device. This has the advantage that with reduced reliability (likelihood of error about 10⁻⁶) the engine is still fully functional with a single micro control device and all the monitoring and control functions are fulfilled. Moreover if the disadvantage of reduced reliability is permanently accepted then there can be a further

advantageous reduction in costs, space requirement and weight in omitting the second micro control device altogether.

In a preferred control process, the operation is carried out with a main cycle at a cycle time of 20 to 100 milliseconds and with say four sub-cycles with a control time t, of 5 to 25 milliseconds. All the long term functions can be processed in the main cycle and the short-term cycles can be accommodated in the 10 sysub cycles. This control concept advantageously And the reduces the idle times and provides greater stability. The of Wiggireserves for the control devices with the land of the great transfer to the first

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Shaft fracture monitoring belongs preferably in while with cycle short term cycles, operating with cycle times of 15 from t_R/4 to t_R/10. However, these short cycle times can only be achieved in short sequence by means of the solution of the invention if the control and monitoring

Cycle times preferably of t_R/2 to 2t_R are provided - for monitoring overshoots of rotational speed, since this error requires no short-term reaction, as does a shaft fracture. Before reactions are triggered, i.e. before the selected micro control device is interrupted by means of the data signal line, in order then to block the supply of fuel, the operation is carried out for the sake of safety with 3-to-5 fold confirmation.

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The different exertion of influence on the engine by co-operation of the micro control devices and the downstream logic switch is divided essentially into two In one case the actual state of the fuel supply is frozen, i.e. it is neither increased nor decreased; in the other case the supply of fuel is abruptly In both cases, however, operators are given the possibility of operating the fuel supply manually.

Provision is always made for freezing when

statistical errors occur in the sensor technology or the microelectronics, or when temporarily switching over from one micro control device to the other. Complete blocking of the fuel supply is necessary with sudden shaft fracture or with sustained excessive rotational speed.

In another embodiment of the invention the stepping motor is operated via four phase supply lines with four phases which are controlled by means of a 10 driver, and four-pole switching selectively by the first or the second micro control device when a selection signal is present at their outputs. This method of operation, known in principle, has the advantage in conjunction with the invention that a simple, cheap and 15 deasily installable solution can be found for the stepping motor, and hence of the position of the stepping motor, and hence of the position of the stepping motor by means of relay-contacts in the first logic switch.

With this logic switch, which has to be located in front of the switch for change-over of the functions of the two control devices so that both one and the other can exert the same influence on the engine when the functions are swapped, an influence on the engine is not produced in every case when a faulty operation of the micro control devices themselves occurs. Therefore an error signal at one of the outputs of the micro control devices preferably causes freezing of the position of the stepping motor and hence the position of the metering valve by applying a stop voltage of 12 to 48 V at one of the phase supply lines of the stepping motor by means of relay contacts of a third logic switch, this third logic switch being arranged after the switch-over device.

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In the case of a fast cut-off upon shaft fracture the non-selected second micro control device as the auxiliary control device preferably interrupts the selected first micro control device in its main cycle by means of a signal line, and causes it to switch over to shaft fracture mode. After independent testing by the first micro control device and confirmation of the The second shaft fracture, an output signal is generated at the second second second United Application of the Second of the sec il on the wife to be fuely metering valve: And the family of the way of the way of the way of the first of the

to follow the land season solutions for controlling shaft power drive to the season season The later than the later assemblies ensure on the onethandathat there is no because the later than it is been a state of inactive redundancy in the aircraft and on the other was a section of on the law was 15 Mars handssafety and reliability are substantially greater, all and the law to

a substitute of the invention will now be a section of the invention will now be a section of the invention ignerically assessed described with reference to the accompanying drawings, Astronomy with the contraction of the contraction o

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Fig. 1 shows a partial circuit, diagram for a preferred embodiment of the invention with a control device for switching over the engine control and for freezing the supply of fuel; and

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Fig. 2 shows a partial circuit diagram for a preferred embodiment of the invention with a control device for blocking the supply of fuel in the case of shaft fracture, excessive rotational speed or other serious engine defects.

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Fig. 1 shows a partial circuit diagram for a preferred embodiment of the invention with a control device for switching over the engine control and for freezing the supply of fuel to a shaft drive assembly, having at least one micro control device or processor 1

for controlling the metering of fuel by means of a metering valve 10, controlled by a motor drive 8 via several signal-selection logic blocks 4, 5, 6, 7, and 22 in Fig. 2, such as a channel switch-over logic 6, two freezing logic circuits 5, 7 and a channel switchoff logic 22, as indicated in Fig. 2, with monitoring of the engine for shaft fracture and excessive rotational speed by means of sensors

use of two micro control devices 1 and 2; with which the interfaces for a with the interfaces for a with the line of the line o with the supplied to the supplied of the controlling fuel supplied and for the motion of the The fast cut-off of a blocking valve, such as for Translated to 2,0 for the supply of fuel are already installed. The supply of the supp

The outputs of the micro control devices 1 and 2, which was a second of the micro control devices 1 and 2, w enamely A_{F21} or A_{F22} for freezing the fuel supply A_{F1} or the supply and the supply are the supply and the supply are the supply and the supply are the App for freezing the fuel supply when a malfunction of the second supply when a malfunction of A second of the sensor technology or of the micro control devices the technology of the The state of an error in both channels, the state of an error in both channels, the state of the 20 Asi or As2 for the selection of one of the micro control \sim devices as the regulator of the fuel supply, and A_{soci} or A_{soc2} in Fig. 2 for a fast cut-off of the fuel supply in the case of shaft fracture or excessive rotational speed, are conveyed by means of power end stages T_{Pz1} and T_{Fz2} , T_{F1} and T_{F2} , T_{S1} and T_{S2} , and T_{SOC1} and T_{SOC2} respectively in Fig. 2 into the signal-selection-logic 5, 6, 7 as shown in Fig. 1 and 22 in Fig. 2. Accordingly, a first and a second micro control device 1, 2 are coupled together and locked in partial functions with respect to each other.

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The first micro control device 1 as the selected control device controls, for instance, a stepping motor 8 which drives the metering valve 10. The selection of the micro control device 1 is effected via the switchover block with the selection logic 6 by the relay S1 which is assigned to an output A_{s_1} of the micro control

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device 1 or by the relay S2 which is assigned to an output A_{s2} of the micro control device 2. The relays S1 and S2 are locked with respect to each other and coupled in such a way that the following logic is reliably achieved for the channels K1 and K2:

- 1. channel K1 selected AND channel K2 off:
- 2. channel K1 off AND channel K2 selected;
- 3 channel K1 off: AND channel K2 off:

A property 10 seems systems have a total failure and this case both seems to the second outputs Ag or Ag are set at error potential and the with the through control phases Ph1-4 of the stepping motors stota fixed property with the 。 ・ 東西大統領5 - Apotential V_r and hence freeze the position of the particle o with the and the amount of fuel supplied, i.e. the fuel supply and the supply

中国大学中心 1000 For controlling the stepping motor 8 the channels (4) 1000 stepping 20 4 K1 and K2 have in this instance four phases Ph, Ph2, the state of the contract of the con Ph₃, Ph₄ on the supply lines to the stepping motor, one of the phases being channelled through a first 🗯 🤲 . selection or relay logic 5 for freezing the current fuel supply. This logic 5 ensures that in the case of an error not identified by the selected channel, the non-selected channel may prevent a critical error function for the shaft power drive assembly. Freezing is effected by one of the four phases here Ph_4 , being set to the already mentioned fixed potential Vp, which in this example is between 12 and 48 V, with 28V being selected here.

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Consequently the second micro control device 2, which in this case is connected as the auxiliary control device, can monitor the permitted boundary data of the engine and for this purpose is equipped with the driver outputs A_{S2} , A_{F2} , A_{F22} shown in Fig.1 and A_{SOC2} in

Fig. 2.

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For the sake of completeness, a manual emergency control device 9, already known for devices of this kind, has been integrated into the preferred exemplary embodiment of Fig. 1, and makes it possible for the operator to switch over to manual operation. At the same time this is an example of how the control device of the invention can be integrated to advantage into existing installation and regulation concepts. A combined the contract of the

·治療性は10 学者を Fig 22 shows a partial circuit diagram of a 国際の行った ので あり さんかんかん The preferred embodiment of the invention, with a control second the laws. The supply of fuel in the case of the case Shaft@fracture; excessive rotational speed or other had a similar result of the control of the c Strive Burpose an emergency to the engine defects. For this purpose an emergency to the second of the life The first of shutdown valve 23 for the fuel is actuated withe file of the state of the file of the fil The Control for the emergency shutdown valve 23, is designed Mary to a southat the micro control device not selected for the time to be a time as control of the stepping motor monitors the rotational as a second with the second control of the stepping motor monitors the rotational as a second control of the stepping motor monitors the rotational as a second control of the stepping motor monitors the rotational as a second control of the stepping motor monitors the rotational as a second control of the stepping motor monitors the rotational as a second control of the stepping motor monitors are second control of the second control of the stepping motor monitors are second control of the stepping motor monitors are second control of the second contro speeds measured by the sensors for shaft fracture and े के कि 20 े के excessive rotational speed in a short cycle of about े कि 0.5 to about 6 ms, in this example 2 ms. If this type of faulty functioning of the engine is identified, this second micro control device sets its output A_{soc2} and by means of the data signal line \mathbf{I}_{21} causes an interruption 25 in the running of the control procedure for controlling the fuel supply in the first micro control device. This device in turn, somewhat delayed (about 0.5 ms), also carries out this test for shaft fracture, for instance, and accordingly controls its own output Asocn. When both micro control devices 1 and 2 have set their outputs A_{SOC1} and A_{SOC2} the emergency cut-off is activated by means of the relay logic 22. Mistaken emergency cut-off of the engine due to an electrical malfunction is therefore extremely unlikely.

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If one of the two micro control devices 1 or 2 fails, the contact of the associated relay F1 or F2 is

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closed and the entire authority via the emergency shutdown valve 23 is transmitted to the error-free micro control device 2 or 1.

In the case where both micro control devices 1 and 2 fail, both F-relays are closed (fall away) and the emergency cut-off relay SOC can no longer be The likelihood of the coincidence of a double error in the device and a fracture of the shaft compact to the contically zero, to a reserve the continue of t

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The embodiment according to Fig. 2 assumes two and promise according to Fig. 2 assumes two and promise according to Fig. 2. engines with shafts independent of each other. The the transfer of the state of th The second engine with a second engine with a second emergency shutdown the second engine with a second emergency shutdown walve_24.4 By controlling the emergency cut-off relay to the second of the controlling of the controlling of the controlling the emergency cut-off relay to the second of the controlling of the controllin 15 SOC first of all the emergency cut-off of the second of the second grant the emergency cut-off of the first engine is triggered. Safety and reliability are therefore increased because the following safety recommendation of the requirements are guaranteed: The recommendation of the second content of the second cont

- 1. When one engine is switched off; the second of the land of the second engine can no longer be switched off;
- With simultaneous triggering of the switch-2. off both engines, neither of them may be switched off.

The downstream bistable relay 20 means that once started an emergency switch-off can only be reset by the flight personnel.

Control of the two micro control devices is effected in two different modes. The first micro control device 1 selected for control of the engine runs the control programme which is responsible for control of the stepping motor 8, in one mode at a cycle or period of about 20 to 100 milliseconds, in this The second non-selected micro control example 50 ms. device 2, used for monitoring the characteristic data of the engine, runs the control of the monitoring, for

instance for shaft fracture and excessive rotational speed, in one mode at a cycle or period of 0.5 to 6 ms. In addition, monitoring of the engine operating point is effected as a background.

On identifying the shaft fracture the output Asocz is immediately set and at the same time the first micro Fig. control device is interrupted by means of the data signal line I2 in the running of the intended fuel was a second of the intended fuel was a second of the second of order to a think as supply regulation has the ordered of a first two \$1.500 freelings when the content of the

Total When the engine has reached an impermissible with the engine ार्किक के Mark Toperating point, such as excessive rotational speed; के कार्क कार्क कर कर है। April of the state of all in this example the output April of the state of the excessive rotational speed, if excessive rotational speed, we The transfer of the speed still applies a few milliseconds later, and this where the contract the speed still applies a few milliseconds later, and this where the contract the speed still applies as few milliseconds are the speed still applies as the speed still applies as few milliseconds are the speed still applies as the speed still applies are the speed still applies as the speed speed are the speed speed at the speed speed speed at the speed speed at the speed speed at the speed speed at the speed speed speed at the speed speed speed at the speed speed speed speed at the speed The first the specific confirmed 3-to-60 fold, the output A_{soc2} with the specific and the associated emergency switch-off relay SOC is set. This division of control in accordance with the common the second The second of the second configuration of the second confi 2007 Se low expenditure on hardware, both to control the engine and assessment the with short idling time and to carry out effective monitoring of shaft fracture and excessive rotational speed.

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Claims

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A control system for a shaft drive assembly, including:

a pair of micro control devices (1,2) for controlling the metering of fuel; and

means for monitoring the drive assembly for shaft The difference of fracture and/or excessive rotational speed;

The state of the micro control devices (1) acts to the micro control devices (1) The first was the selected control device controlling the fuel of the second device List - Charles an auxiliary control device monitoring the critical The same of the drive assembly and is equipped with outputs as exampled with soutputs with the fuel setting for one (Agg) Agg) for freezing the fuel setting for one and the series of the working of the series Secretary and 15 dry serious, kind of fault, the selected and the auxiliary of the law was the control device (1, 22) being coupled together in such a the second variation way that the functions can be alternately switched over the functions can be alternately switched over the solve of the between the two control devices in the solve of which we have the

いた。 コート・マル集 すってが2字 - A control system according to claim 1 pand 。 この時代の歌歌のは、 着。 further including first and second logic switches (5, salabeles) was and 22), in which the first switch, (5) mediates the output was demand. for freezing the fuel setting and, by means of a transistor driver (T_{SOCI}, T_{SOC2}) , the second logic switch (22) triggers the fast cut-off and makes possible a delayed cut-off by means of the second logic switch (22), and in which the functions are switched over according to the setting of the first and second logic switches (5, 22).

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- A control system according to claim 1 or 2, in which the control devices are coupled together by means of the first and second logic switches (5,22) and an additional direct data line (I_{21}, I_{12}) .
- A control system according to any preceding claim, in which the fast cut-off is triggered by the auxiliary control device and is effected by the selected control device.

- A control system according to any preceding claim, in which both micro control devices (1, 2) can fulfil all the functions as individual devices when there is a total failure of one control device, but the monitoring function for shaft fracture in this case is carried out slowed down by a factor of 3 to 10.
- A control system according to any preceding claim, in which the control is effected with a main to the control is effected with a main to the control is Fig. - walligg or with Alsubscycles at apperiod the offs to 25 A 40 Marting the Caracagnetic a inverse and in milliseconds resigned to the control of the control
- which the shaft fracture monitoring is carried out in a monitoring is carried out in a monitoring is a second out of a monitoring is a monitoring in a monitoring is a monitoring in a monitoring is a monitoring in a monitoring in a monitoring is a monitoring in a monitoring in a monitoring in a monitoring is a monitoring in a monitor on all the sub-cycle of periodit, 4 to t_1/10 to t_1/10 to te children in the confidence of the site of the con-
- 34.8 A control system according to claim 60or 770 2 450 450 450 460 460 The wife of in which the rotational speed is monitored within a first speed as wife Here was the confirmation. The parties of the confirmation of the

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the control state of the state of the control system according to tany spreceding to the system and 家 and red 20, you claim, in which the control device controls the fuel by Marsharth and w means of a metering valve with a stepping motor drive and by means of channel cut-off logic.

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- 10. A control system according to claim 9, in which the stepping motor (8) is operated by means of four-phase supply lines $(P_{h1}, P_{h2}, P_{h3}, P_{h4})$ which are controlled by means of a driver (3, 4) and four-pole switching (6) selectively by the first or second micro control device when a selection signal is present at their outputs (A_{s1}, A_{s2}) .
- 30 A control system according to claim 10, in which freezing of the position of the stepping motor and hence of the position of the metering valve is effected by applying a stop voltage of 12 to 48 V at one of the phase supply lines $(P_{h1},\ P_{h2},\ P_{h3},\ P_{h4})$ of the 35 stepping motor (8) by means of relay contacts (F_{z1}, F_{z2}) in the first logic switch (5).

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A control system according to claim 10 or 11, in which an error signal at one of the outputs (A_{P1}, A_{P2}) of the micro control devices (1, 2) causes freezing of the position of the stepping motor and hence the position of the metering valve by applying a stop voltage of 12 to 48 V at one of the phase supply lines $(P_{h1}, P_{h2}, P_{h3}, P_{h4})$ of the stepping motor (8) by means of relay contacts (F1, F2) in a third logic switch (7).

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- TOWNS 13. A control system according to any preceding to the backet of the claim, in which in the case of a fast cut-off upon the first of a first shaft fracture the non-selected second micro control who the posses of the device: (2); acting as an auxiliary control device, a way a larger and a control device. interrupts the selected first micro control device in a last control de its main cycle by means of a signal line Invand The a remain of a signal line Invance and tswitches it over to shaft fracture test mode, and after the second of the windependent testing by the first micro control device ... And the control device ... W(1) and confirmation, an output signal (Asoci) at the property we will a first micro control device (1), via the second logic switch (22), switches off the drive assembly by blocking the fuel metering valve? The state of the blocking the
 - A control system according to any preceding we have a second claim, in which the first and second micro control devices (1,2) are joined together and locked with respect to each other in partial functions.
- 15. A system or method for controlling a shaft drive by means of two equivalent micro control devices, one for carrying out the routine control of the fuel metering and one for the monitoring of faults, the latter applying suitable override functions when certain faults are detected, in which the two micro control devices are adapted to be interchangeable so that the control function can be performed by the former monitoring device and vice versa.
- 16. A system or method for controlling a shaft drive by means of two equivalent micro control devices, one for carrying out the routine control of the fuel

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metering and one for the monitoring of faults, the latter applying suitable override functions when certain faults are detected, in which both micro control devices are capable of performing both the control and the monitoring so that in the case of failure of one device the other can maintain control 是一点,是一点, and monitoring intact.

- 接触機能能力 - 等 17% An engine control system substantially as ちゃん カーカータン・カータン と 1 - Approximation and escribed herein with reference to the saccompanying (名の表現) 動き は approximation (名 Part Part Compared the Compared Compared to the Compared Compared

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